

# Development of MgO templates for coated conductors using ion-beam assisted deposition

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# IBAD MgO attractive for commercial scale up

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## *Advantage*

IBAD MgO/ $\alpha$ -Si<sub>3</sub>N<sub>4</sub> forms an oriented template at the nucleation stage with optimum texture at  $\sim 100$  Å ( $\sim 100$  x faster than IBAD YSZ)

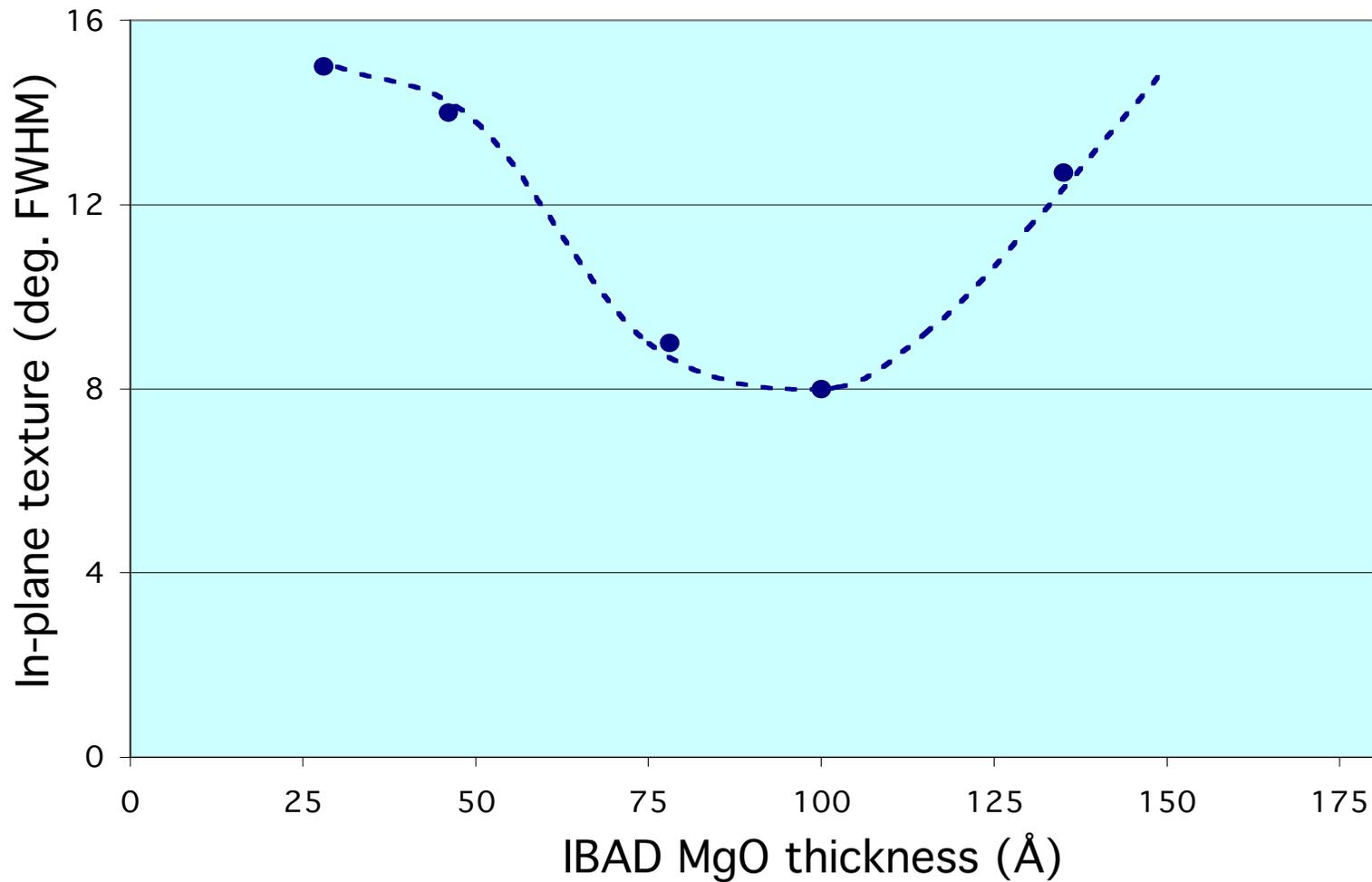
## *Issues*

Narrow processing window

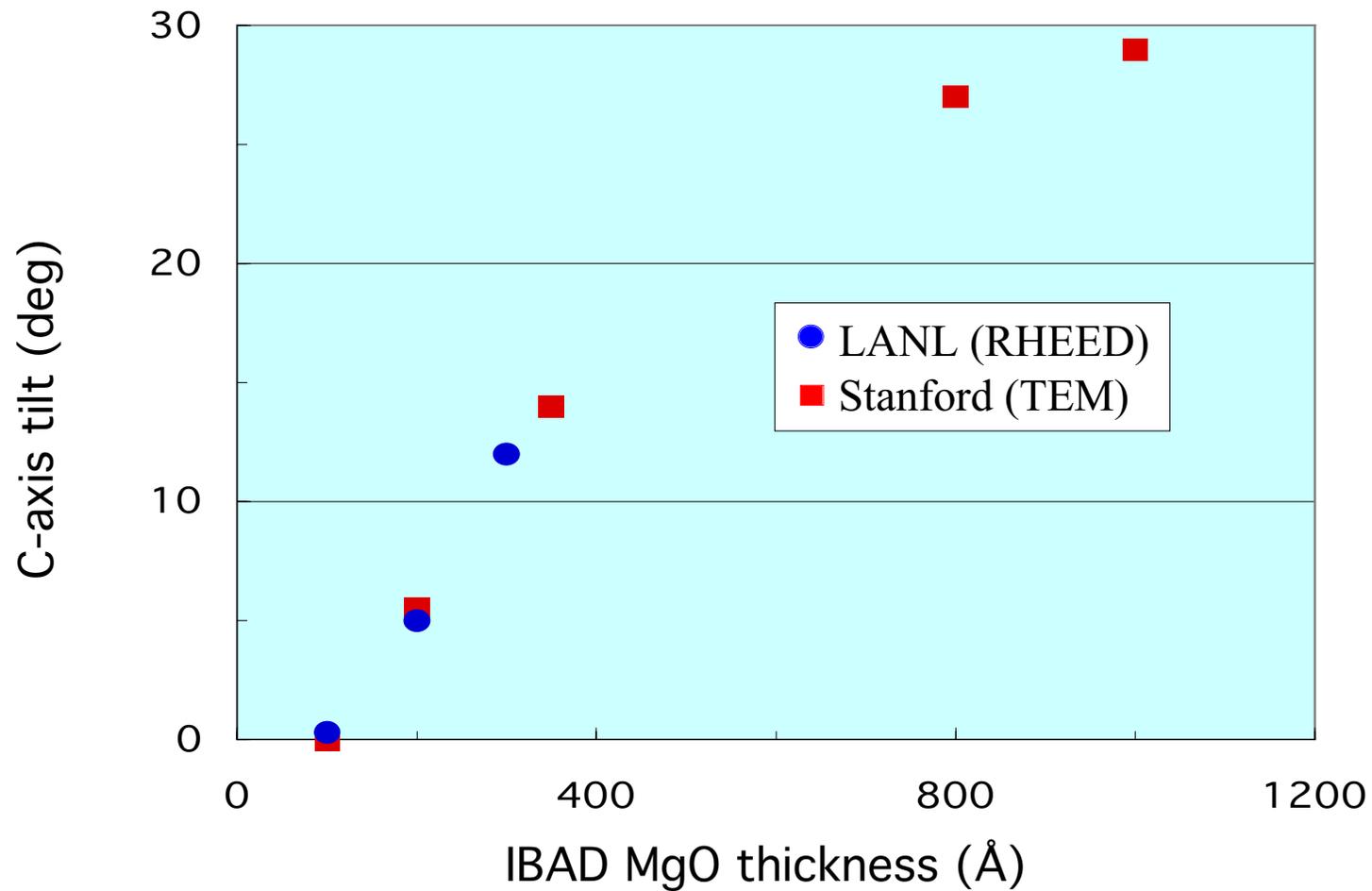
Very thin template requires smoother substrate than thicker IBAD materials (e.g. YSZ, Gd<sub>2</sub>Zr<sub>2</sub>O<sub>7</sub>)

Optimum buffer layer(s) not defined

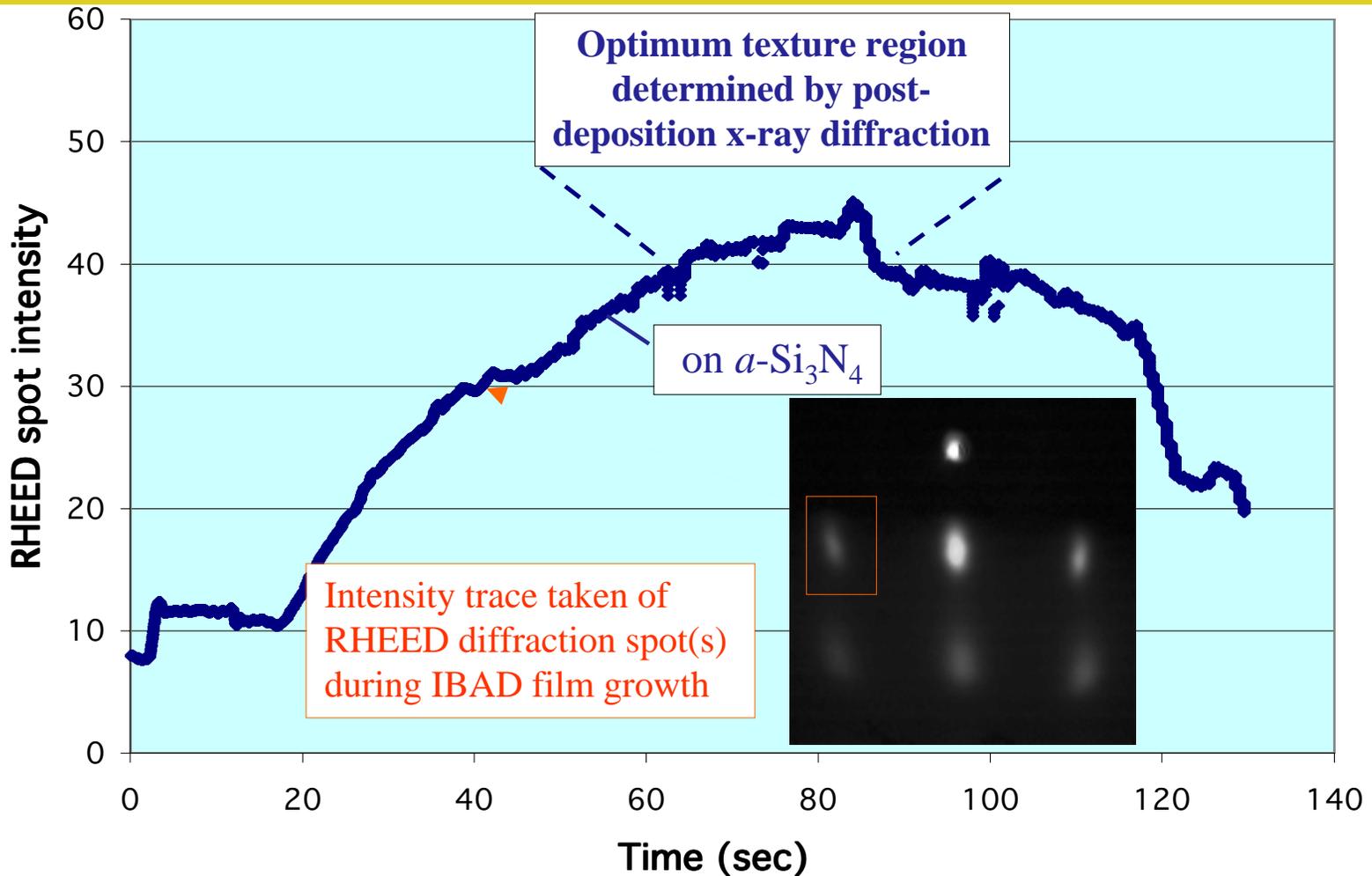
## Optimum texture for IBAD MgO/*a*-Si<sub>3</sub>N<sub>4</sub> restricted to relatively narrow thickness range



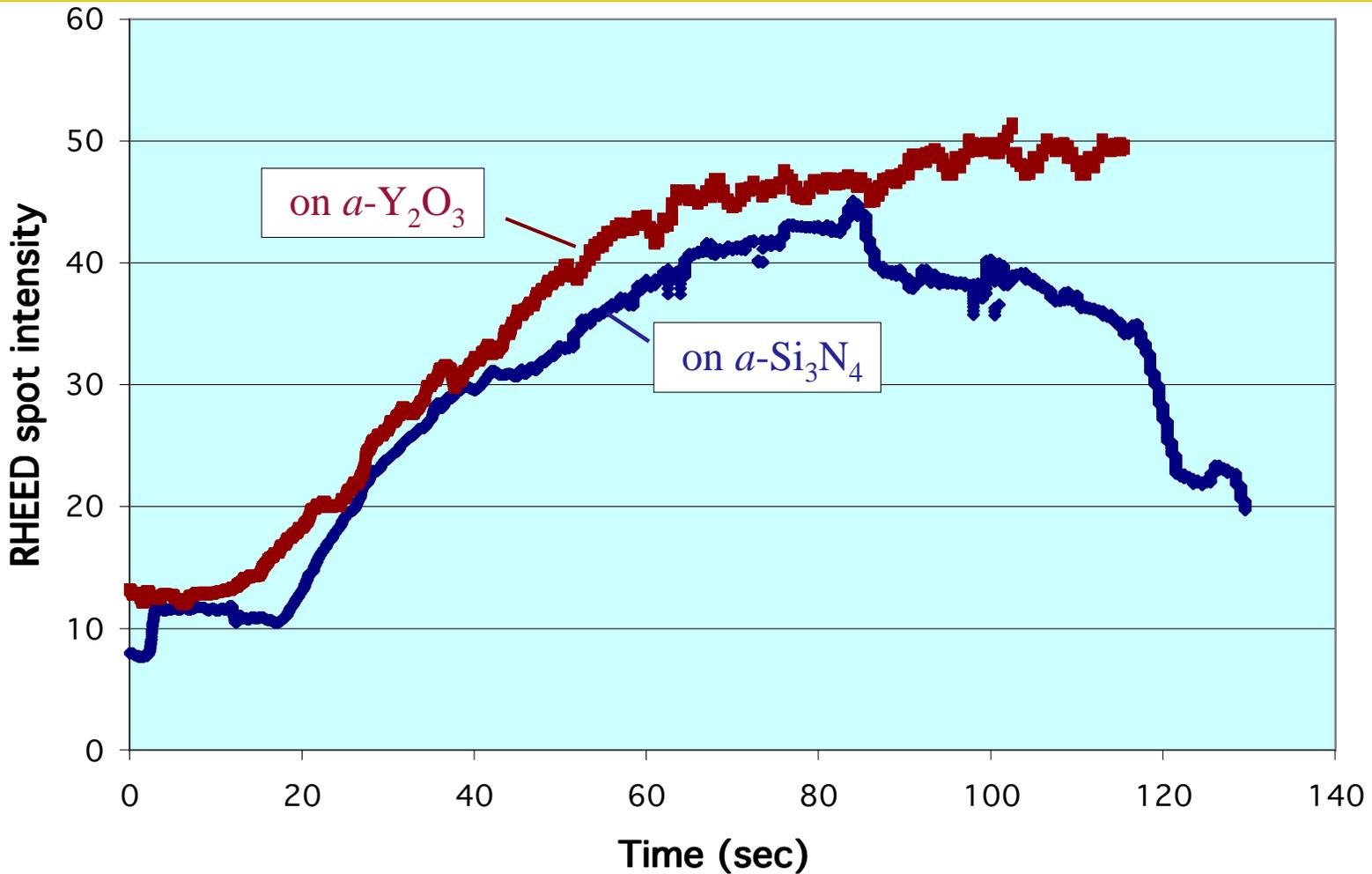
## C-axis tilt beyond 100 Å could account for texture degradation



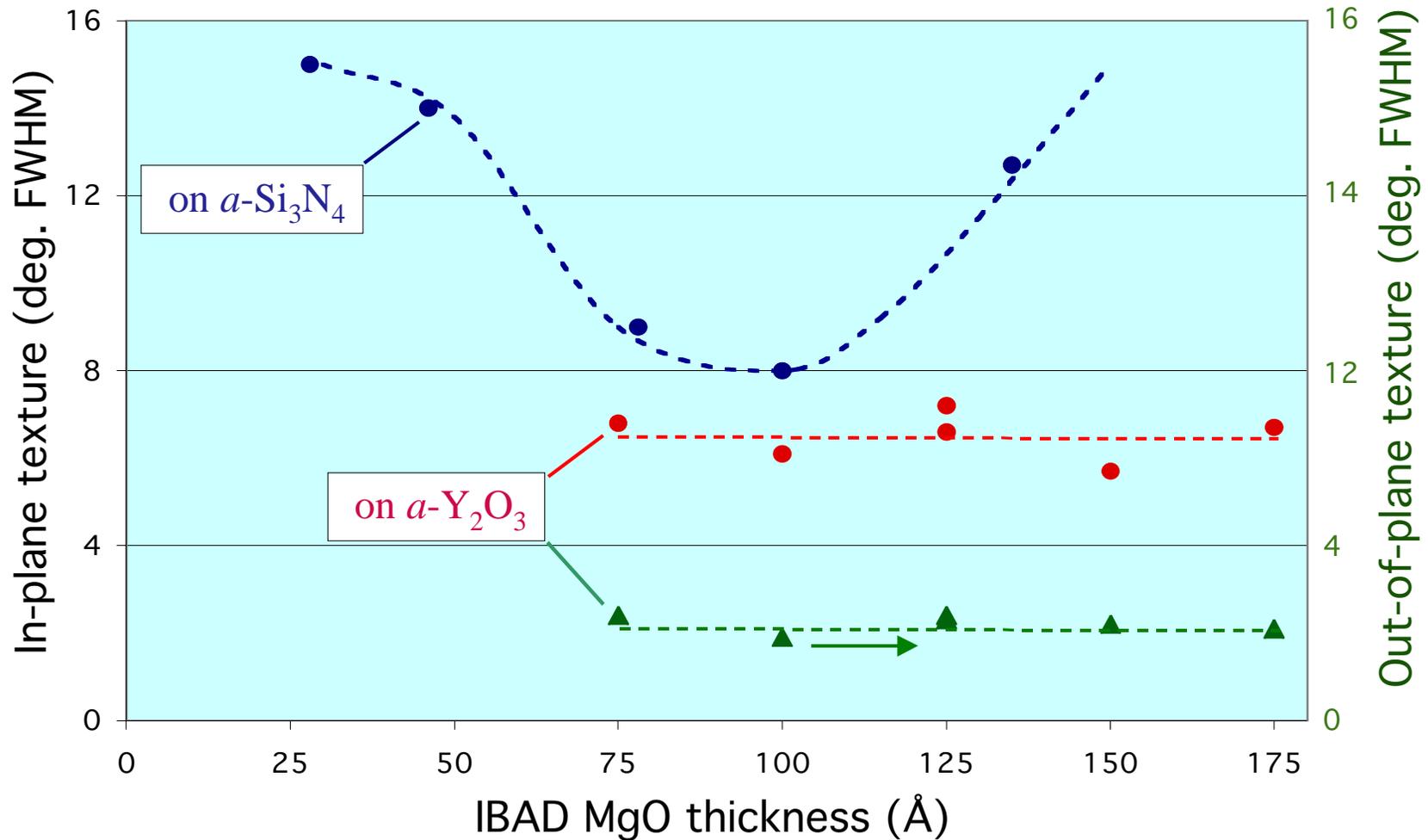
# Optimum texture of IBAD MgO/ $\alpha$ -Si<sub>3</sub>N<sub>4</sub> may be obtained using RHEED monitoring of diffraction spot intensity



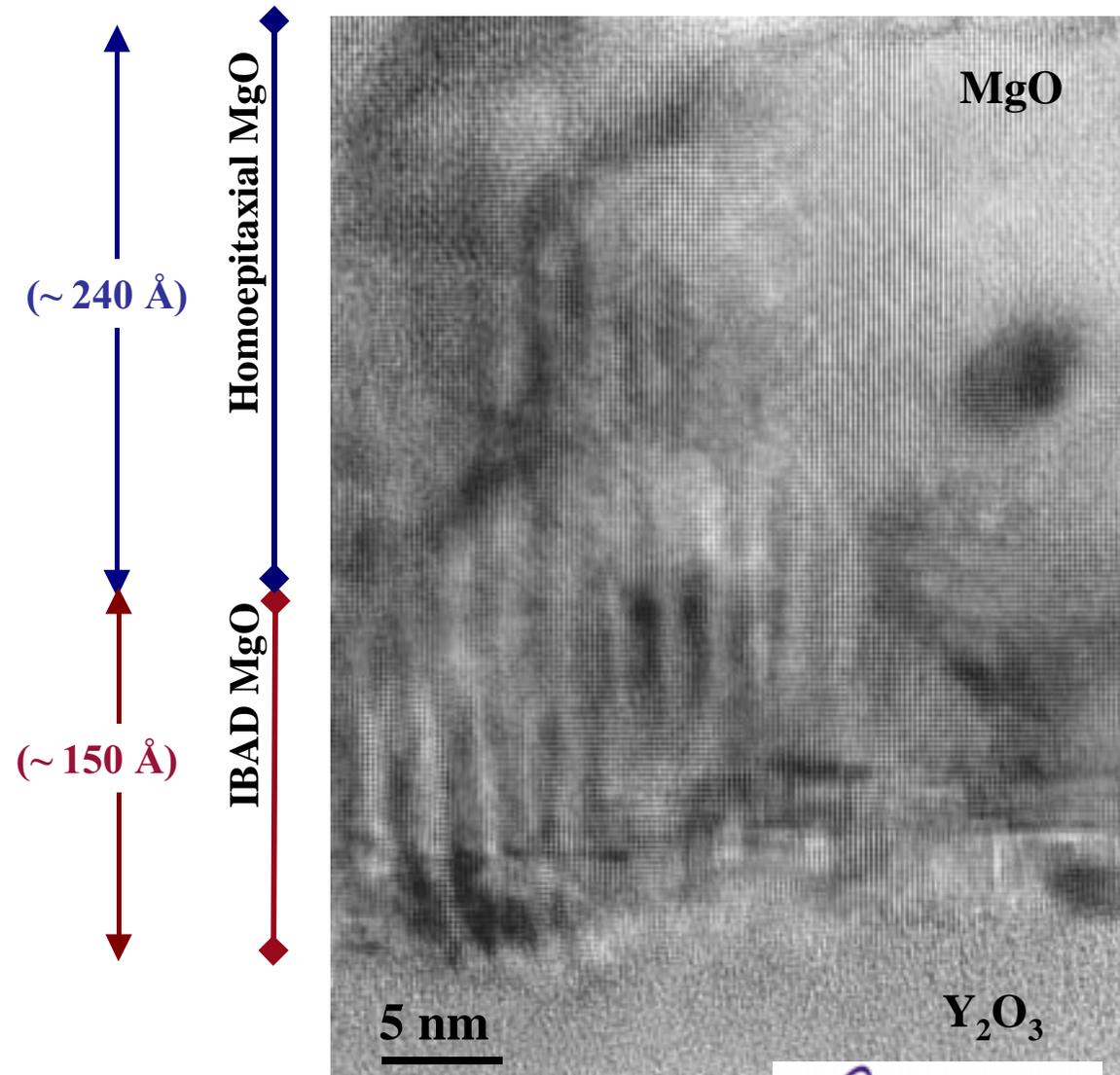
# Type of amorphous nucleation surface influences IBAD MgO growth



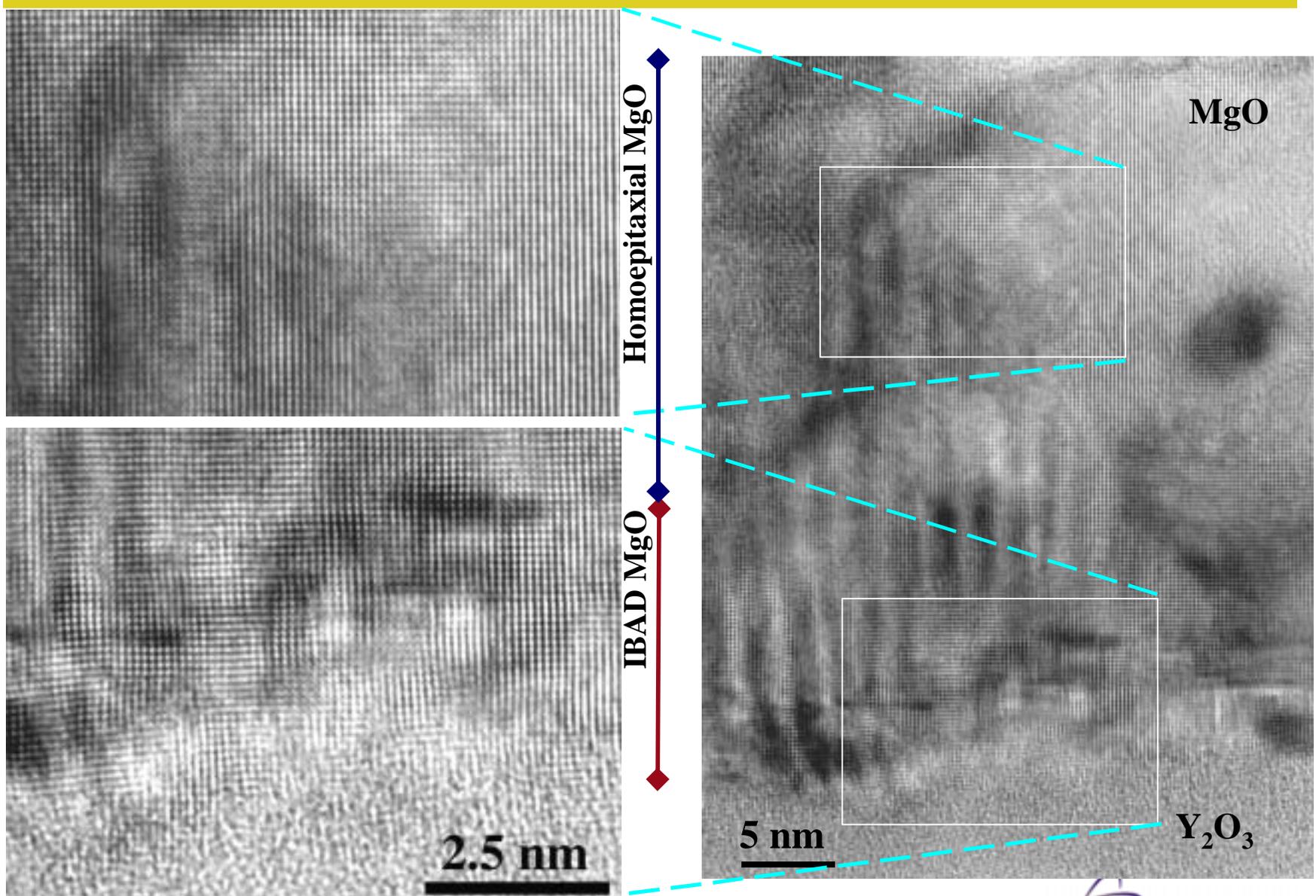
# Optimum texture for IBAD MgO/*a*-Y<sub>2</sub>O<sub>3</sub> obtained over larger thickness window



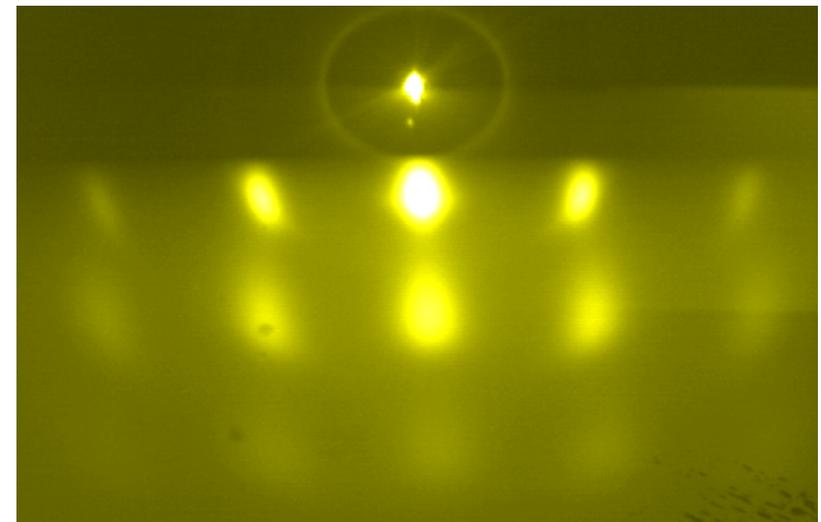
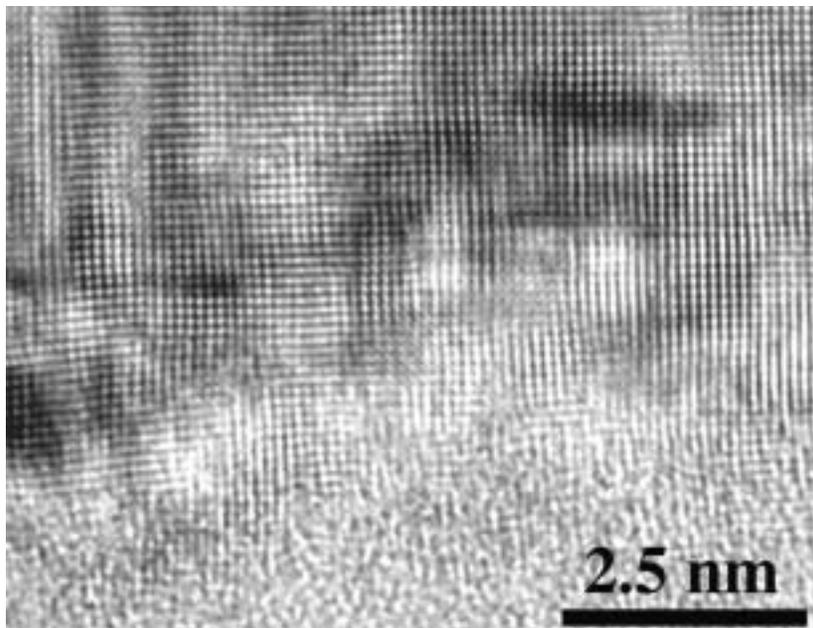
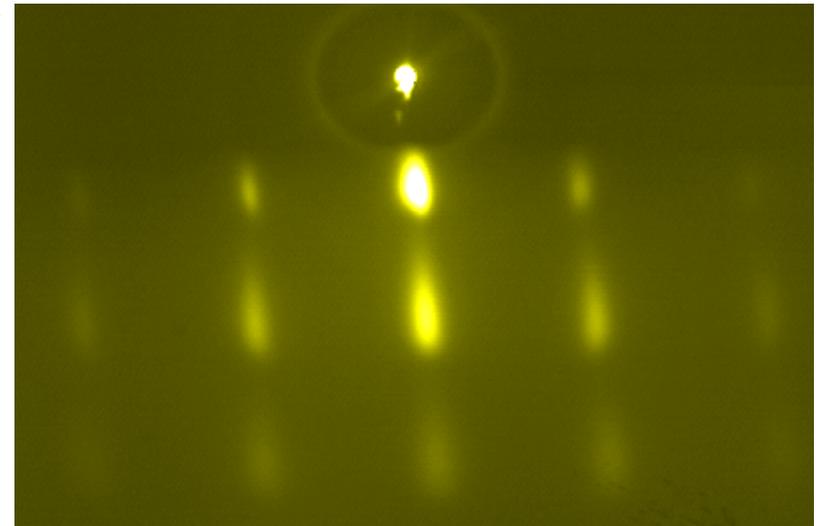
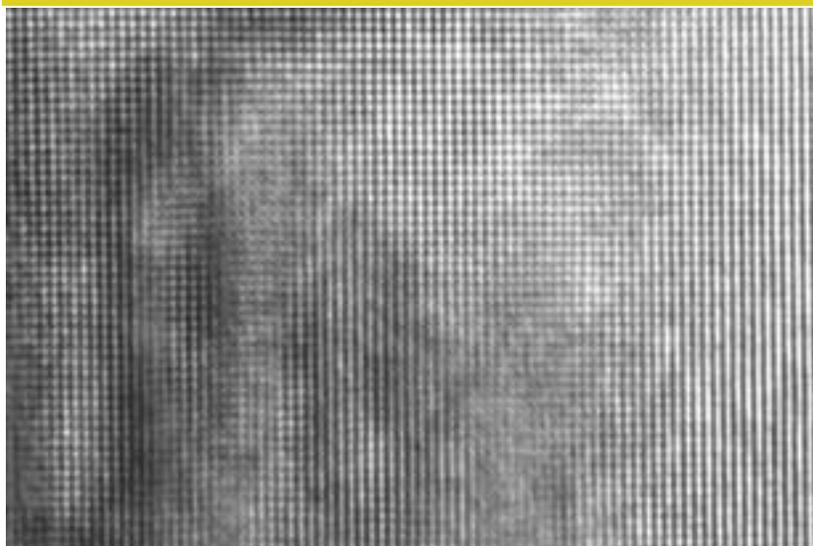
# TEM cross section of homoepitaxial MgO/IBAD MgO/ $\alpha$ -Y<sub>2</sub>O<sub>3</sub>/Ni-alloy



# High resolution TEM cross section shows fewer defects in homoepitaxial layer compared to IBAD MgO layer

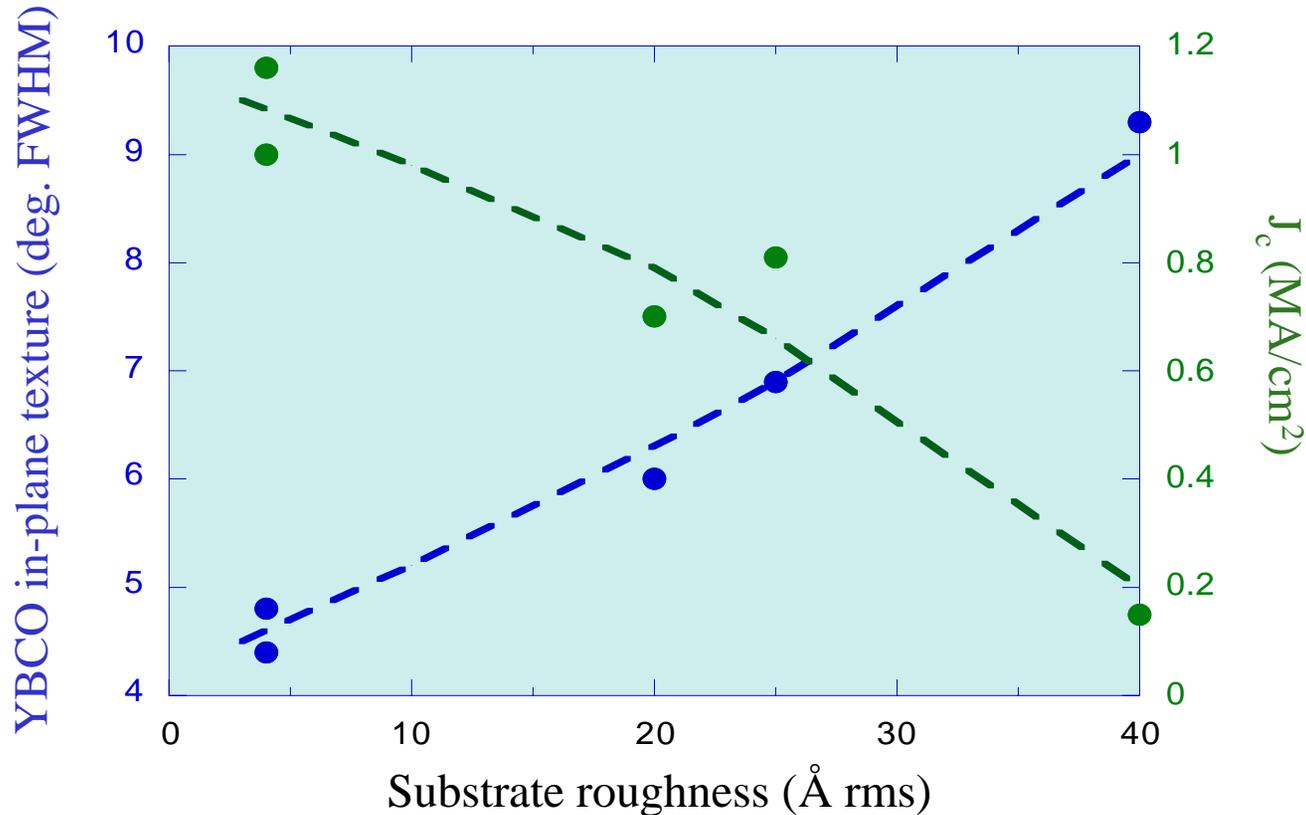


## RHEED patterns confirm fewer defects near the surface of homoepitaxial layer compared to IBAD MgO layer



# Substrate roughness must be minimized to optimize YBCO/IBAD MgO texture and performance\*

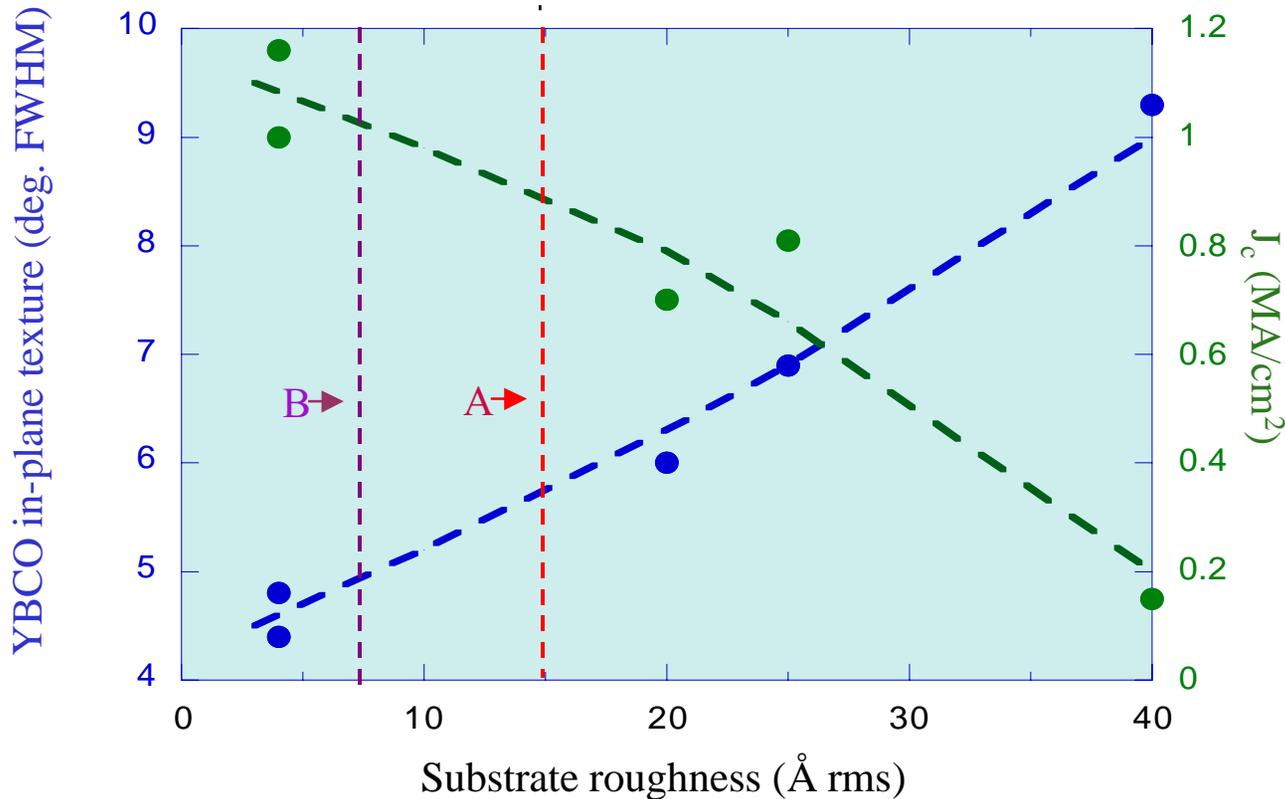
YBCO/CeO<sub>2</sub>/YSZ/homoepi-MgO/IBAD MgO/a-Si<sub>3</sub>N<sub>4</sub>/orbital polished-C276



\* Proc. Int. Workshop on Superconductivity, Honolulu, HI, p. 43 (2001)

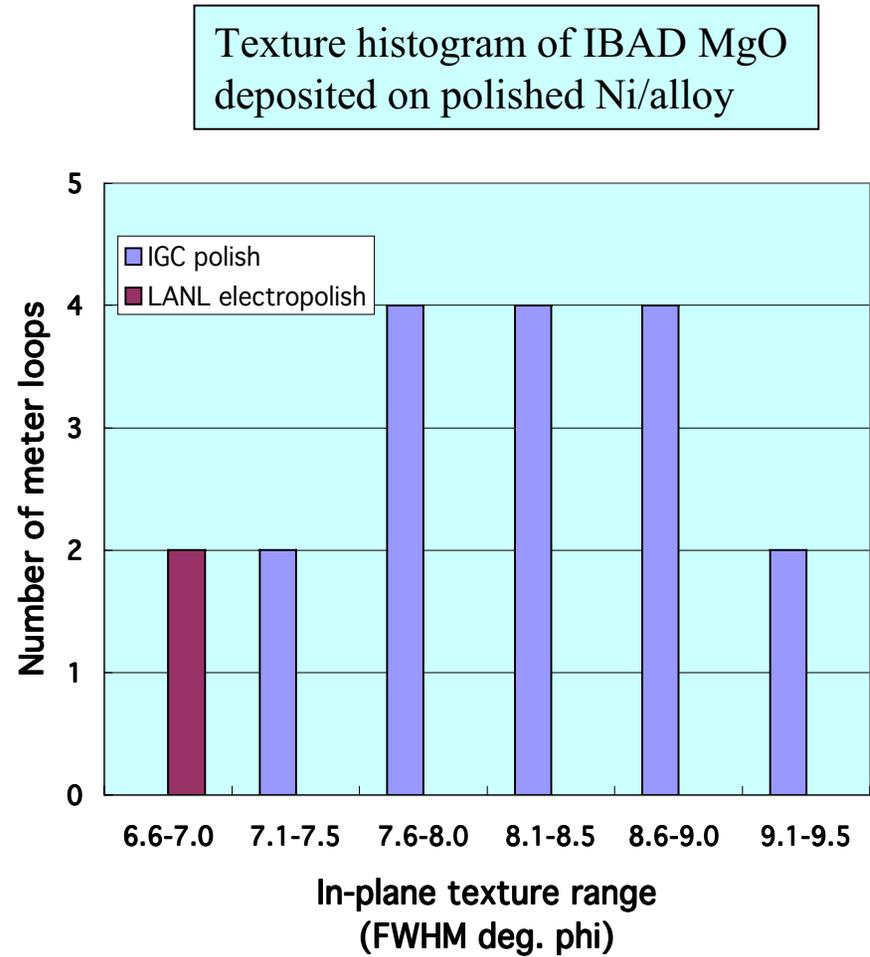
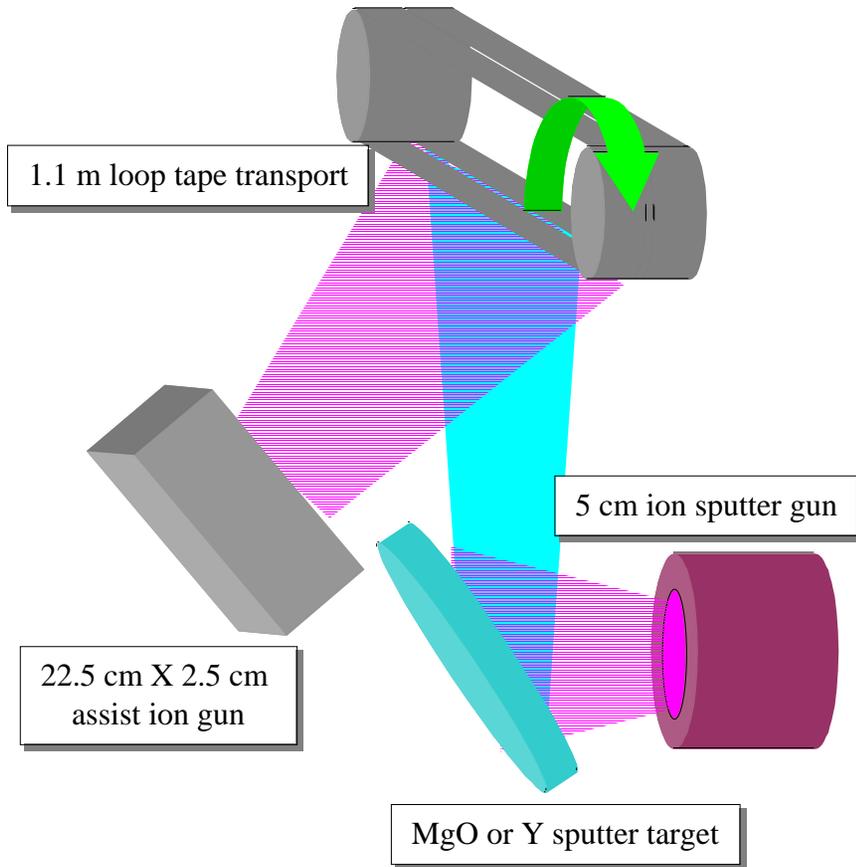
5 x 5 μm AFM scan area

# The desired substrate finishes are being achieved in reel-to-reel polishing systems



- A. Typical finish achieved by IGC Superpower reel-to-reel polish system (IGC has supplied 100 m lengths of polished tape to LANL)
- B. Finish demonstrated in LANL reel-to-reel electropolish system

# Texture histogram of meter-length loops show reasonably good in-plane alignment values



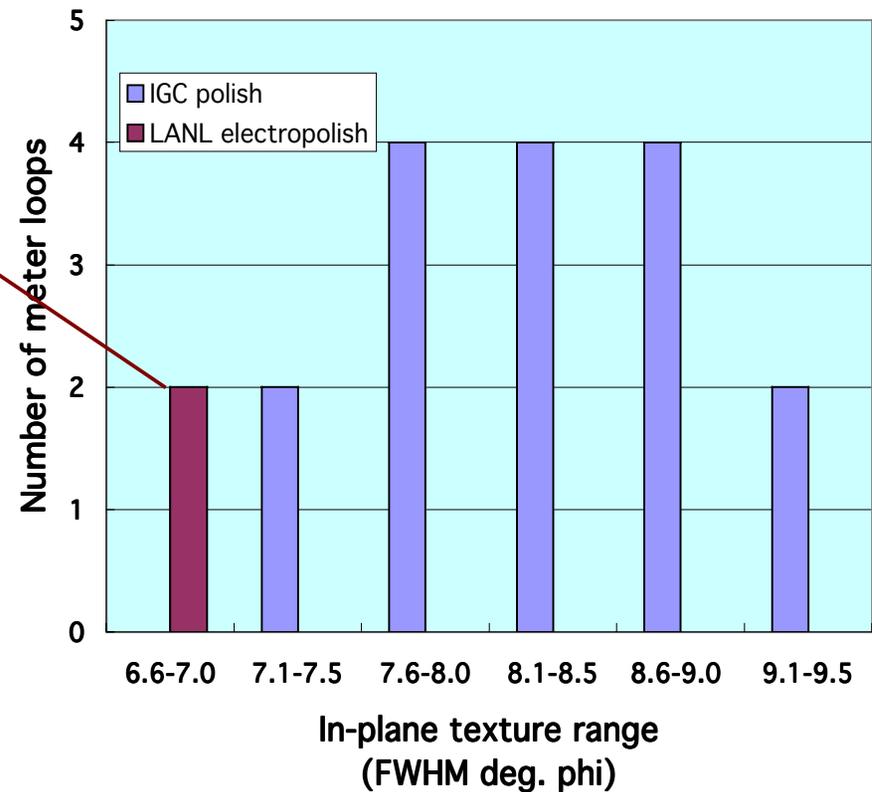
# Texture histogram of meter-length loops show reasonably good in-plane alignment values

A short piece from one of these IBAD MgO/Ni-alloy electropolished tapes was coated with PLD YBCO

MgO in-plane FWHM =  $6.6^\circ$   
MgO out-of-plane FWHM =  $2.8^\circ$   
YBCO in-plane FWHM =  $4.9^\circ$   
YBCO out-of-plane FWHM =  $1.5^\circ$

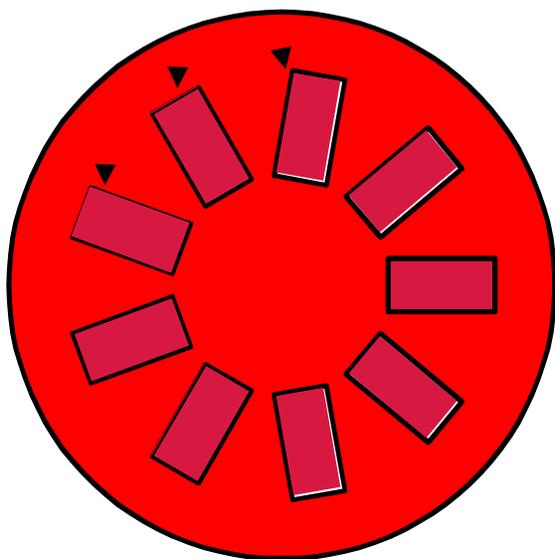
$J_c$  (75 K, s.f.) =  $1.5 \text{ MA/cm}^2$   
YBCO thickness =  $1.65 \mu\text{m}$   
Equivalent  $I_c \sim 248 \text{ A/cm-width}$

Texture histogram of IBAD MgO deposited on polished Ni/alloy



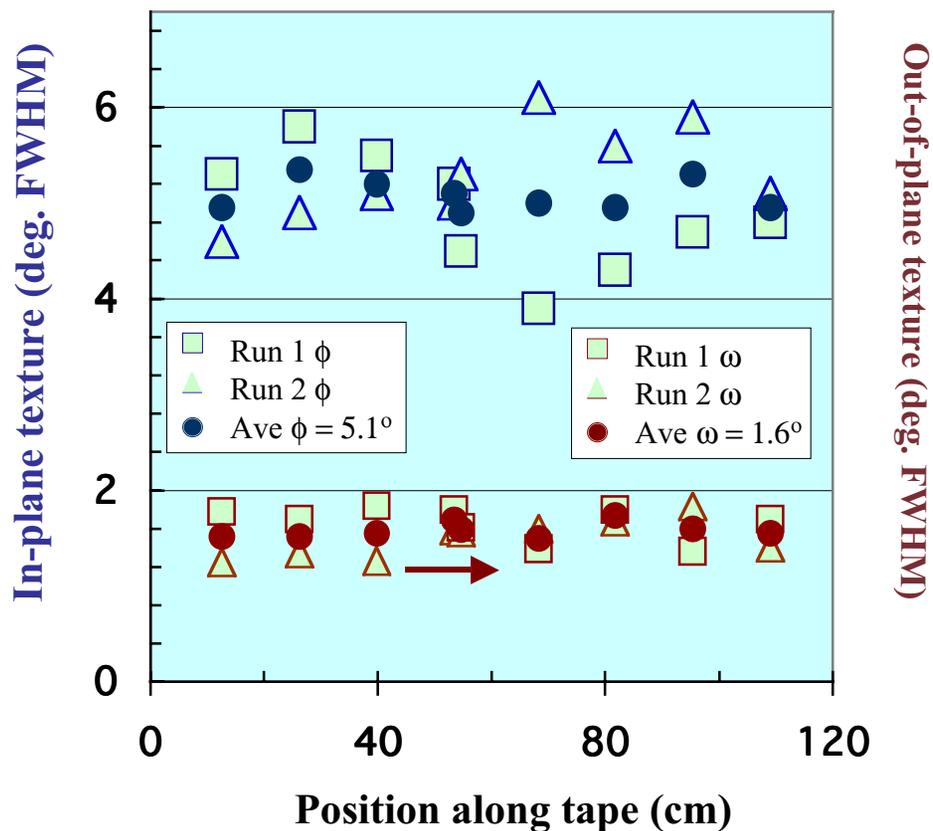
# Texture uniformity for meter-length IBAD MgO/Ni-alloy tapes obtained through measurements of YBCO

Nine 0.5 x 1 cm pieces cut along length of meter and mounted on heater in PLD system

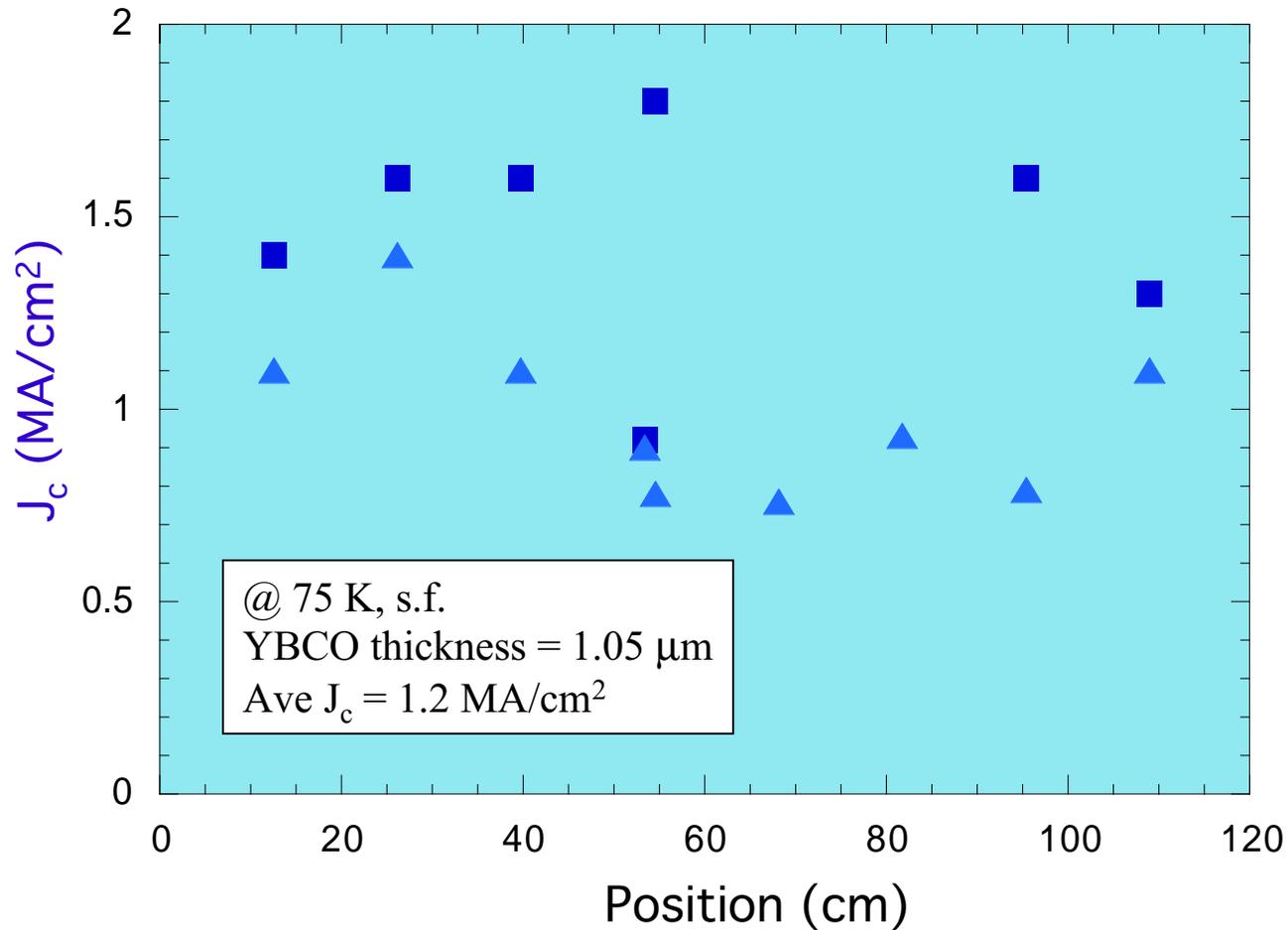


Substrate heater

After 2 YBCO deposition runs, XRD of individual samples was performed



## Narrow bridge $J_c$ measurements were also performed on each of the samples



# Summary

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Amorphous  $Y_2O_3$  nucleation layer expands IBAD MgO processing window and eliminates need for in-situ RHEED monitoring.

Industrially-scalable electropolishing of Ni-alloy tapes provides very smooth substrates and results in high  $J_c$  YBCO on IBAD MgO.

Continuous-mode IBAD MgO produced 18, 1.1 meter lengths with in-plane and out-of-plane textures of  $6.6^\circ$ - $9.5^\circ$  and  $2.5^\circ$ - $3.7^\circ$  degrees, respectively.